SOME FEATURES OF THE RECENT EARTHQUAKE.

SOME knowledge of the local topography and geology in the vicinity of Charleston is essential to a complete understanding of the effects of the great earthquake.

The seaboard portion of the coastal plain, upon which Charleston, Summerville (twenty-one miles to the north-west), and the other towns most seriously affected by the recent catastrophe, are situated, is a nearly uniform plain from ten to thirty or forty feet in altitude, slightly inclined seaward, and diversified by broad, irregularly meandering, and inosculating troughs and pond-like depressions from five to fifteen feet deep. The depressions, or 'low-grounds' as they are termed colloquially, are frequently swampy, and toward the ocean merge into the tidal channels of the coast; but, when above the reach of the tide, they are lined with a rich semi-alluvial soil, either supporting luxuriant arboreal vegetation, or producing abundant crops; while the uplands constituting the plain proper (the 'high-grounds' or 'pine-barrens' of the rural population) have a light, sandy soil little charged with humus, and are naturally forested, chiefly with pine. This slightly accented topography is not the product of sub-aerial erosion and deposition, but was fashioned by oceanic waters as the land emerged from the sea; the high-grounds representing the slightly sloping beaches, and the low-grounds the tidal canals and estuaries, of an epoch during which the land stood from ten to thirty feet lower than now. Summerville is an aggregation of suburban residences irregularly scattered about in a pine-forest on the uplands, and is probably the most elevated point in its longitude between Cooper River on the north-east and the Ashley on the south-west. Ten-Mile Hill (midway between Charleston and Summerville) is on the eastern margin of the same upland, overlooking an irregular depression connecting these rivers; while Charleston is located on the extremity of a peninsular prolongation of the plain, bounded on the north-east and south-west respectively by the Cooper and Ashley rivers, which, by reason of the seaward tilting, is elevated but a few feet above tide.

The geologic structure is remarkably simple, and when the formations have been thoroughly investigated, and definitely correlated with those of other portions of the coastal plain, will doubtless be found wonderfully uniform over a considerable area. The superficial deposit in the uplands is obscurely stratified, fine yellow sand or (rarely) mottled clay reaching a depth of from five to fifteen feet. Beneath this member, and frequently immediately beneath the soil in the low-grounds, occurs a bed of fine clayey sand or silt, generally bluish in color. This stratum commonly contains sulphurets and various salts, either free or quickly liberated on oxidation. It is from ten to thirty or forty feet thick; the precise thickness being difficult to determine, partly because of the local thickening due to depressions in the subjacent surface, and partly because of the impossibility of separating it from the superjacent member: indeed, the superior sand appears to differ from this mainly in the greater amount of oxidation which it suffered. In the low-grounds, and along the coast generally, these sands are overlain or replaced by estuarine alluvium consisting of fine blue silt or clay, locally designated 'pluff mud;' for the land is now subsiding (and apparently most rapidly south-westward), and sedimentation is advancing upon the land. Beneath these superficial deposits occurs the commonly recognized 'marl-bed,' at the summit of which the South Carolina phosphates are found. The superior strata of this marl-bed in some isolated areas have been referred to the later tertiary by Holmes and others; but by far the larger portion of the mass represents the formations made classic by Tuomey under the names of 'Ashley and Cooper beds' and 'Santee marls.' These formations consist of a somewhat variable but nevertheless remarkably uniform succession of marls, clays, and sands, extending to a depth of about six hundred feet where they are underlain by petrographically similar cretaceous deposits, increasing in heterogeneity somewhat downward to two thousand feet below the surface. At this depth a good supply of artesian water has been obtained. The structure at greater depths is not certainly known; but, according to Hall, the fossils from the lowest strata reached by the artesian borings indicate that a considerable thickness of cretaceous strata are infraposed, while there is reason to believe that these, in turn, rest on pre-cretaceous beds.

To one traversing the disturbed area, the effects of the earthquake are themselves no more conspicuous than the indications of inequality and intensity, and variability in character, of the disturbance; and it is this phase of the subject that will be dealt with in the following paragraphs.

1. From the early commencement (Friday, Aug. 27) and the long duration (up to date) of the seismic disturbance at Summerville, from the frequent repetition and great intensity of shocks, from the frequency of detonations and their simultaneity with tremors, and from the vertical direction of the vibrations, that place may be regarded as the centre of disturbance. The predominant effects of the shock of Aug. 31 are,

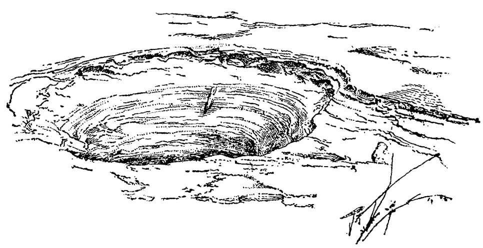

Fig. 1.—Craterlet at Ten-Mile Hill.

Fig. 3.—Torsionally displaced chimney in Charleston.

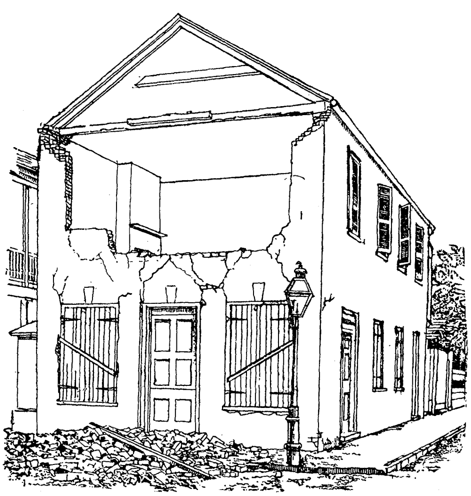

Fig. 2.—Displaced gable in Charleston.

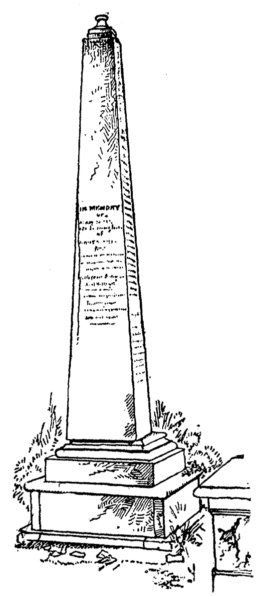

Fig. 4.—Displaced monument in Charleston.

first, fissuring of the surface of the earth; and, *second*, crushing of foundations and chimneys; together with, *third*, slight displacement in different directions (and sometimes torsional) of buildings.

The fissures are irregularly distributed throughout the village and over the surrounding plain. They are generally confined to the high-grounds, but appear to reach maximum abundance about the peripheries of the more elevated lands. They are so numerous that sometimes not an acre in a square mile is free from them, and, three days after the great shock, were two inches and less in width, and from four or five feet to as many hundreds in length. From the testimony of the citizens, as well as from the sand and mud stains in their vicinity, it appears that sand-laden water welled from these fissures in vast volumes, and continued to flow for some hours, and even, in some cases, days: indeed, water was observed to flow freely from one on the highest ground in Summerville up to the fifth day after the great shock during which they are said to have been formed. The local streams were flooded by the water from these fissures, and the floods had not completely subsided a week afterward. The sand and clay washed from them was evidently derived mainly from the uppermost member of the superficial deposits, although in some cases the blue sand of the inferior member predominates. These fissures extend in all directions, and occasionally cross and bifurcate at various angles.

The architecture in Summerville is characteristic: the houses are generally of wood, lightly framed, either partially or wholly surrounded by wide verandas, and supported on slender pillars from four to six feet high, either of wood set in, or of brick built upon, the ground; while the chimneys usually rest on independent brick columns built up from the ground. Few if any of them have suffered injury, save by the great shock of Aug. 31; and the injury to the houses themselves is astonishingly slight, and generally confined to racking of frames, shaking down of plastering, and occasional crushing of roofs by falling chimneys. Much injury was done, however, to furniture, which was overturned, tossed about, and in many cases broken. When the supporting pillars were of wood, the buildings have sometimes been displaced, and the entire structure, including the supports, has evidently swung to and fro in all directions, as indicated by the annular crevices surrounding the pillars; and in such cases the chimneys have almost always toppled over, generally to the north or south, the direction having been determined to a large extent by the slopes of roofs. When, however, the supports were of brick, they have been crushed at top and bottom, and fissured obliquely in all directions, as if by blows of a pile-driver, and in some cases the pillars have been driven into the ground, depressing and concentrically fissuring the surface about their bases. The crushing of the pillars is invariably greatest beneath the heaviest parts of the building: indeed, in some cases the heaviest pillars have completely collapsed, and the buildings are now supported by the piers beneath the verandas and the lighter parts of the floors. The heavy bases of the chimneys are similarly crushed and fissured; and in numerous instances they, too, have completely collapsed, and all that portion of the chimney beneath the roof has crumbled down into a mass of loose bricks, sometimes leaving the projecting portion intact and in place upon the roof. An example of the manner in which structures have been crushed vertically with little lateral displacement is found in the centre of the village of Summerville, where two apparently fragile chimneys, left in position when the building to which they were attached was destroyed by fire years ago, have been crushed and obliquely fissured, but have not been overturned, or displaced laterally to the slightest degree.

The writer experienced half a dozen or more shocks in Summerville, and heard four or five times that number of detonations. The individual shocks were of very brief duration: the longest observed (and from the testimony of the citizens it appears that this was second in severity only to the great shock of Aug. 31) was over in less than thirty seconds. The motions of furniture, etc., during this shock, were carefully noted. It was found, that, during the first two-thirds of its period, the vibration appeared to be directly vertical; that a wrenching, torsional motion, turning objects in the direction of the sun, followed; and that this was succeeded by a few gentle east-and-west rolls. The movements were identical in all the lighter shocks, when of sufficient duration to permit of observation, save in intensity. Ordinarily, however, the lighter shocks were simply spasmodic quivers of but an instant's duration, the direction of which it was impossible to determine. The shocks were invariably accompanied by sensibly simultaneous detonations resembling slightly muffled thunder-peals or heavy cannonading, commonly compared by the older residents, who remembered the bombardment of Charleston, to the booming of 'siege-guns' a mile or two away; but the detonations were three or four times as frequent as the tremors. It may be mentioned that no two individuals, even among trained observers, agreed as to the direction whence the sound came. This fact, and the simultaneity of

detonation and observed tremor, together suggest that the sound came directly from the earth, either as sonorous vibrations, or as soundless pulsations of such period as to be converted into sound-waves on passing from earth to air.

2. The principal physical record of the great shock at Ten-Mile Hill is found in the craterlets, or 'sand-spouts,' which there attain maximum size and abundance. They are simple circular or elongated orifices from which water has welled forth with such violence as to flood the entire surface over hundreds of acres to depths of from one to two or more feet, to carry out hundreds of tons of the yellow and blue sand overlying the marl-bed, and to spread this sand over scores of acres to depths varying from a fraction of an inch to two or three feet. These crateriform orifices are now surrounded by their solid ejecta in annuli attenuating peripherally, in which the shrinking streams from the dwindling fountains have worn channels and gullies, as shown in fig. 1; and most of them are now filled with water up to within a foot or two of the natural surface. By residents the waters are reported to have gushed forth during, and for some hours after, the great shock, sometimes by jets but generally continuously, to the height of trees; and, since they sometimes contained sulphurous compounds, they gave out characteristic odors that added much to the terror of the people. The volume of water extravasated was sufficient to flood many of the minor drainage-ways above even the highest freshet-marks; and five days after the great shock, water still flowed from some of the craterlets, and yet retained the odor of sulphuretted hydrogen. There is no indication that the orifices extend, or that the water flowed from, below the base of the superficial sands (in which the mean depth of permanent ground water is ten or fifteen feet), either at Ten-Mile Hill or elsewhere; and, indeed, at the phosphate-works nearest Ten-Mile Hill, in the immediate vicinity of which both fissures and craterlets occur, the marl-bed was so slightly disturbed at depths of sixty or seventy feet, that the water slowly percolating into the shafts was neither increased nor discolored. Nevertheless, these fountains, issuing from a surface fifteen feet above the level of ground water, the flow from fissures here, at Summerville, and to a less extent at Charleston, and the rise of waters in wells in various localities, all point to sudden and considerable contraction, either vertical or horizontal, of the water-bearing sands overlying the marl. 'Sinks' are, indeed (rarely), associated with the craterlets; but they appear to have been formed after the subsidence of the extravasated floods.

In the vicinity of Ten-Mile Hill, too, the kinking and distortion of railway-tracks is most striking. In a number of cases the rails were so bent as to necessitate removal; the displacement in alignment sometimes reading two feet or more, while that in profile was half as great. It should be mentioned, that, in all personally observed and well authenticated cases of compressive distortion of rails, the kinks occurred in the low-grounds at the bottoms of inclines, and generally in the vicinity of trestle-bridges approached by embankments, and that at least a part (and in one case all) of the contraction relieved by the kinking appears to have been caused by the down-hill settling of rails, ballasting, and embankment. Nevertheless, longitudinal fissures in the embankments, and lateral throw of the track, have evidently been produced directly in some cases: and near Ten-Mile Hill a locomotive was derailed (with destruction of life) during the second shock; but whether by the tremor, or as a result of antecedent displacement of the track, could not be ascertained.

In general terms, the injury to the few buildings at Ten-Mile Hill is similar to that exhibited at Summerville, save that the horizontal displacement has been greater, chimneys have been more generally overthrown, and the plastering of the ceilings is less seriously, and that of the walls more seriously, cracked and dislodged.

It is noteworthy, that, between Ten-Mile Hill and Charleston (perhaps three miles from the latter place), there is a considerable area or zone in which the effects of the earthquake are inconspicuous: chimneys have seldom been overthrown, buildings are not displaced on their foundations, the foundations themselves are not crushed, and plastering is but slightly injured. Even the tall brick chimneys of the fertilizer-works within the area appear to have escaped injury.

3. As has already been made known through the daily press, the most conspicuous effect of the seismic disturbance at Charleston was the lateral displacement and overthrow of chimneys, monuments, walls, entire buildings, etc. These records of the great earthquake have been examined and noted with care, with the view of applying Mallet's method of determining the origin and paths of the seismic tremors to the region affected thereby. The observations on injured buildings may be briefly generalized as follows: —

1. The throwing outward of walls, gables, cornices, copings, etc., is most common in walls facing north, next in those facing south, third in those facing east, and least in those facing west. 2. By far the greater number of overthrown chimneys have fallen either to the north or south, and more to the north than the south. 3. The most seriously cracked walls are those facing east;

those facing west are nearly as seriously injured; those facing south follow, but are much less injured than the two former; and those facing north are least injured, but only slightly less than the southerly walls. 4. When corners of buildings are thrown out, they have gone most frequently to the north-east, next to the south-west, third to the north-west, and least frequently to the south-east. So many isolated observations are inconsistent with these generalizations, however, that little value can be attached to them. Similar inconsistencies are observed in the behavior of the marble and granite shafts in marble-yards and cemeteries. Of those which have been overturned, the larger number have been thrown either to the north or south, but some have gone in various other directions; many have suffered torsional displacement, but of these some have turned with others against the sun; while others are displaced laterally without overthrow, and in as many directions as there are compass-points. Chimneys, too, have been twisted both with and against the sun, and during their oscillations have 'walked' in various directions. A Charleston chimney twisted with the sun, and slightly displaced southward, is shown in fig. 3; and a neighboring monumental shaft turned in the opposite direction, and displaced north-eastward, is represented in fig. 4. Perhaps the discrepancies among these observations may eventually be eliminated, and the apparent confusion reduced to order; but for the present, inferences as to the azimuth of the wave-paths in Charleston and immediate vicinity are premature.

It is remarkable that the intensity of the seismic action has varied greatly within the limits of the city of Charleston. Thus in certain quarters the buildings have escaped with trifling injury, while similar and similarly oriented buildings in other quarters have been completely destroyed; and all possible intermediate phases of injury are found in different parts of the city. The numerous observations on the variable intensity of the disturbance in Charleston and elsewhere in South Carolina have not yet been collated and digested; but it would appear that there are large areas within which the intensity of the disturbance culminated (and Charleston is one of these), and, moreover, that within these areas themselves there are foci or nodes of maximum vibration circumscribed and separated by annuli in which the disturbance was less severe.

A few fissures, such as those abounding at Summerville, occur in Charleston and vicinity, and some small craterlets have also been observed in the neighborhood.

A number of slight tremors were experienced in Charleston. They differed from those felt at Summerville, 1°, in less intensity and greater duration; 2°, in direction, which was manifestly more nearly lateral than vertical, though the azimuth was not accurately determined; and, 3°, in the absence of detonations or other sounds than such as might be attributed to movements in furniture, in neighboring buildings, etc.

Briefly, it appears, that within a radius of a dozen miles somewhere near the centre of the district affected, and within an area of remarkably uniform topographic configuration and geologic structure, the effects of the recent earthquake are quite diverse: viz., that at Summerville the principal effects are crushing of structures in the vertical direction, and the formation of fissures with the outflow of a considerable volume of water; that at Ten-Mile Hill, half-way between that point and Charleston, the principal effects are local deformation of the surface and the extravasation of a great volume of sand-laden water, with combined crushing and lateral displacement of structures; and that in Charleston the predominant effects are lateral displacement in various directions (without vertical crushing) and overthrow of structures, torsional displacement and overturning in different directions of monuments, together with some fissuring of the surface and the extravasation of small quantities of water.

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COMPRESSED AIR ON CABLE-ROADS.

ONE of the minor annoyances in connection with the cable street-railway system is the fact, that, until the car is gripped to the moving cable, it must depend for its motive power upon some other agent; that is, it must be run to and from the car-house by hand or horse power; and switching from one track to another at the termini of the road is usually accomplished in the same manner. To dispense with this extra motive power, by making each car temporarily self-propelling, is the object sought in a series of experiments now in progress on the Tenth Avenue cable-road in this city. The experimental car is fitted with a small air-compressor, an air-engine, and several cylindrical air-tanks, placed beneath the body of the car. The compressor is connected by a clutch with one of the car axles; and the engine or motor is connected in a similar manner, though with the addition of an intervening train of speed-reducing gear-wheels. On a recent trial trip, the air-tanks were filled to a pressure of about five atmospheres, at the car-house, by means of a compressor. The driver, or grip-man, then opened the valve admitting air to the engine, and the car propelled itself